Nonomura and Hu Reply: In the preceding comment [1], Olsson and Teitel questioned the possible vortex slush (VS) phase in the frustrated XY model with point defects reported by the present authors [2]. The VS phase was originally proposed in order to explain an experiment of irradiated $YBa_2Cu_3O_{7-\delta}$ (YBCO) [3]. This phase was also observed in an optimally-doped pristine YBCO [4], where the VS phase locates above the Bragg glass (BrG) phase in the H-T phase diagram. In Monte Carlo simulations of the frustrated XY model by the present authors [2], a first-order transition was observed between the vortex liquid (VL) and VS phases up to a certain density of point defects. The structure factor in the VS phase shows obscure Bragg peaks, which was interpreted as a short-range order in the ab plane. In comparison with the BrG phase for lower density of point defects, the VS phase shows much larger density of dislocations in the ab plane and the vanishing helicity modulus along the z axis.

Olsson and Teitel simulated the same model for the same parameterization as used in Ref. [2]. On the basis of the structure factors observed in layer by layer, they argued that the VS phase observed by the present authors may be an artifact of a finite system size, and that this region may be included in the BrG phase in the thermodynamic limit. However, their argument in the Comment is not justified sufficiently by the provided numerical data for the following reasons.

First, they observed strong hysteresis behavior by sweeping the pinning strength of point defects ϵ in the VS region, and took this behavior as the evidence for a wide coexistence region of the first-order melting of the Bragg glass. However, this behavior can alternatively be interpreted as merging of the consequent VL-VS and VS-BrG first-order phase transitions due to a small system size. The two-step behavior in the hysteresis curve of the peak value of the structure factor in Fig. 1(b) of Ref. [1] looks consistent with the latter picture. It should also be pointed out that the hysteresis behavior may be enhanced by their ϵ-sweeping procedure. Since the annealing process is not included in this procedure in spite of possible drastic changes of the configurations of flux lines caused by varying ϵ, Monte Carlo steps necessary for equilibration in this procedure may be much larger than those in the temperature sweeping adopted in our previous article [2].

Second, they argued that the energy loss due to a mismatch in different layers is proportional to $J_z L^2$ with the transverse system size L. This scaling argument is based on the assumption that the mismatch characterized by the change of peak positions of Bragg peaks occurs as abruptly as a domain wall of the Ising model. However, the mismatches displayed in Fig. 2 of Ref. [1] relax across a number of layers. When the relaxation takes place across L_w layers, the energy loss is proportional to $J_z L^2/L_w$. It is natural to expect that L_w depends on the thickness of the system L_z. Provided L_w is proportional to $L_z \sim L$, the energy loss caused by a mismatch is proportional to $J_z L$, instead of $J_z L^2$. Then, their conclusion should be changed completely [5]. In order to address the issue sufficiently, one should vary the system size and check the size dependence of the relaxation between mismatches and the number of mismatches.

On the other hand, we have to say that our previous study [2] cannot completely exclude the possibility that the "first-order VL-VS phase boundary" may actually be the melting line of the finger-like wiggled BrG region stretching into the VL phase [6]. Such a narrow BrG region (see Fig. 1 of Ref. [6]) may be weakened by thermal fluctuations and the inverse-melting behavior may be masked by finite-size effects in numerical simulations or by some experimental conditions. Even if it is the case, the shape of the vortex phase diagram is qualitatively different from that obtained by Olsson and Teitel [7].

We also notice that the vortex phase diagram including the VS phase as Ref. [4] was also reported in a YBCO thin film [8], and that there exist several theoretical studies [9, 10, 11, 12] consistent with our numerical results.

In summary, the scaling argument which plays a key role in the preceding Comment cannot be sufficiently justified by the provided numerical data. Their data are indeed consistent with our previous article.

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